Fort Peck Flow Modification Study

The pallid sturgeon population below Fort Peck Dam in the upper Missouri River consists entirely of aging adult fish. Recruitment of young fish into the population has not occurred for many years. It is hypothesized that regulated flows from the dam coupled with a suppressed water temperature regime during the spring and early summer severely limits the amount of habitat suitable for pallid sturgeon spawning.

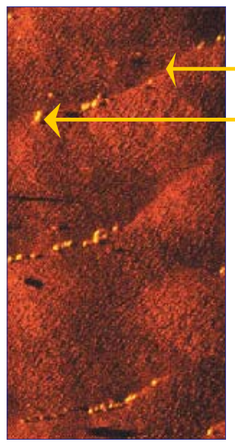
In 2000, CERC facilitated the development of a study plan for evaluating whether flows out of Fort Peck Dam can be changed to allow sturgeon to spawn successfully. In 2001, State and Federal partners initiated the *Fort Peck Flow Modification Study* by collecting baseline data. The long-term study is designed to examine the influence of proposed flow and water temperature modifications from Fort Peck Dam on physical habitat and the biological response of pallid sturgeon and other native fishes. The response of larval, juvenile and adult fish will be integrated with environmental variables such as temperature and water flow before and after the implementation of controlled releases from Fort Peck Dam. Findings from this study will be used to adaptively manage reservoir releases to most effectively enhance spawning success and survival of larval pallid sturgeon.

Preliminary baseline findings show that water temperatures are reduced by 6.3^{o}C immediately downstream from Fort Peck Dam. Suppressed water temperatures are still evident 190 miles downstream from the dam.

Though fish sampling efforts netted thousands of larval fish, only 24 were larval sturgeon. Based upon larval fish collection results, a statistical power analysis was conducted and the sampling design was refined for studies in 2002.

One hypothesis for the lack of pallid sturgeon recruitment was predation by other fish, but dietary analysis of eight piscivorous fish species failed to indicate predation on sturgeon larvae or juveniles.

Side-scan sonar equipment was deployed at the confluence of the Missouri and Yellowstone Rivers to image bottom habitat and native fishes. Gravid female pallid sturgeon collected for hatchery broodstock at the confluence were accurately characterized using ultrasound techniques developed on lower river shovelnose sturgeon, but endoscopy was not effective for these large adults.



Using "side-scan sonar" technology allows biologists to determine the presence of benthic (bottom) fish dwelling in troughs of undulating sand on the bottom of the Missouri River.

Reproductive Studies
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observations and ultrasonic and endoscopic imagery of the gonads were recorded. Histological samples were taken in some cases. Combining ultrasonic and endoscopic imagery and histological data with steroid profiles should provide the ability to determine sex as well as reproductive stage in these fish.

Blood samples and imagery were obtained from pallid (3) and shovelnose sturgeon (380) that were collected from the Missouri River during this yearís sampling. Preliminary results indicate that ultrasonic imagery methods can consistently identify shovelnose sturgeon females and males in spawning condition and that these methods are effective in determining sex and reproductive stage.

To help understand spawning conditions, scientists use non-lethal ultrasonic imagery to determine the pallid sturgeon's reproductive status.

Gonad of a shovelnose sturgeon showing abnormal hermaphrodism. Ripe eggs (black) and testes were on opposite ends of the same gonad.

Interestingly, approximately 3% of the sturgeon captured had morphological characteristics of both shovelnose and pallid sturgeon. These observations may indicate that these two species have hybridized. If hybridization is occurring, it may be because: 1) pallid sturgeon are very rare and may have insufficient numbers to allow successful spawning; and 2) spawning conditions and habitats of both species may overlap in the Lower Missouri River resulting in some cross breeding.

Additionally, 15 of the 380 shovelnose sturgeon evaluated in this study exhibited abnormal, hermaphroditic gonad morphology (photo above). Further research will be required to determine why this condition is occurring and if pallid sturgeon are similarly affected.

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Pallid Sturgeon Investigations

Recovery of the Missouri Riverís endangered pallid sturgeon is a difficult task that requires a scientific understanding of the complex interactions between the ecological requirements of a very rare species and the physical processes of a large river ecosystem. Reproduction, survival and successful recovery of this species depend upon the seasonal availability of the appropriate habitat and environmental conditions.

At the USGS Columbia Environmental Research Center (CERC) researchers study the reproductive biology of the pallid sturgeon, relations of reproductive development to environmental conditions, how pallid sturgeon use habitat, and how much sturgeon habitat is available in the river. Integration of these multi-disciplinary studies will be used to identify spawning cues and physical habitat needed for successful reproduction and recruitment. This information is essential for the design and evaluation of cost-effective management strategies.

CERC pallid sturgeon investigations focus on two geographically different parts of the Missouri River ñ the lower river between Kansas City and St. Louis and the upper river between Fort Peck Dam and the headwaters of Lake Sakakawea (fig. Map). Scientific approaches in the two areas share many characteristics but differ in some respects because of different environments and collaborations. On the lower river, CERC scientists emphasize development of

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biological research tools, quantification of habitat availability, and exploration of sturgeon responses to existing variation in flow and other environmental variables. In the Fort Peck reach, CERC is involved in an interagency assessment of an experimental flow release from Fort Peck Dam designed to enhance pallid sturgeon spawning success. This study will document fish responses to specific, controlled changes in flow and temperature.

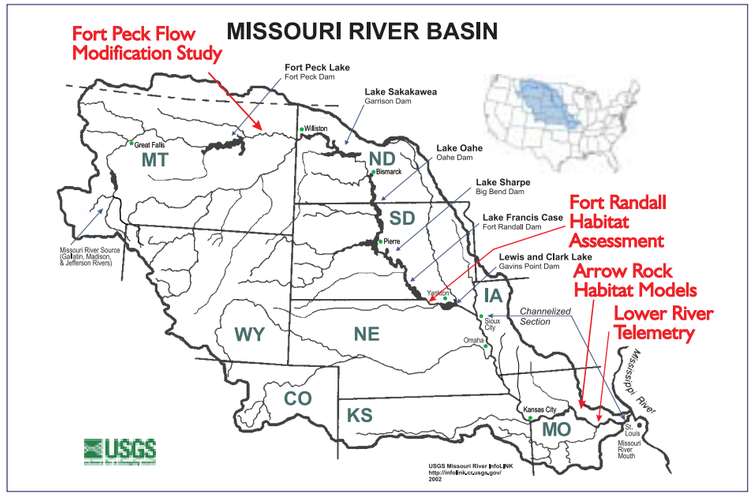

Figure: Map

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CERC web page - http://www.cerc.usgs.gov/
Missouri River InfoLINK - http://infolink.cr.usgs.gov/

Reproductive Studies

The recovery of pallid sturgeon populations requires an understanding of the reproductive status, spawning occurrence, and habitat requirements for spawning and early life stage development. Scientists at CERC are developing methods to determine pallid sturgeon sex, age, and reproductive status. These include blood steroid and vitellogenin levels, anatomical and histological gonad observations, and endoscopic and non-invasive ultrasonic imagery.

In 2002, sampling of shovelnose sturgeon was done to develop monthly profiles of reproductive development. Blood was collected from each fish to develop steroid profiles for 17-beta estradiol and 11 keto-testosterone, hormones important in gonad maturation and gametogenesis (egg and sperm development). Gross anatomical

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Habitat Availability

Pallid sturgeon recovery depends on an improved understanding of river habitat dynamics: how much physical habitat is available, how discharge and channel morphology combine to create habitat, how new habitats can be engineered, and the quality of habitats needed to support particular species. CERC hydrologists quantify and model river habitats using an array of acoustic and computational tools. Hydrologists quantify aquatic habitats by mapping depth, velocity, and substrate. Habitat quantification tools directly address how habitat varies with discharge, thereby providing information for answering fundamental management questions: is more habitat maintained at needed times of year by altering reservoir releases or by altering channel morphology?

Hydrologists are testing habitats models using two different approaches in a Missouri River pilot study near Arrow Rock, Missouri. The first method uses discharge ñ water-elevation relations developed onsite to quantify the availability of shallow-water habitat at Jameson Island (fig. A). The analysis shows that habitat rehabilitation is successful in increasing sandbar area, but shallow-water habitat (thought to be important for rearing of larval and juvenile pallid sturgeon) is in short supply at typical late-summer discharges (fig. B).

The second method involves implementation of a hydraulic model to inventory habitat over longer reaches of the river. Habitat inventories provide a scorecard for assessing present-day habitat availability and measuring habitat improvements as a result of rehabilitation projects. The habitat inventory model can calculate acreages of depth-classes for a wide range of discharges (fig. C). Work is progressing on 2-dimensional hydraulic modeling that will add inventories of velocity classes as well as depth classes.

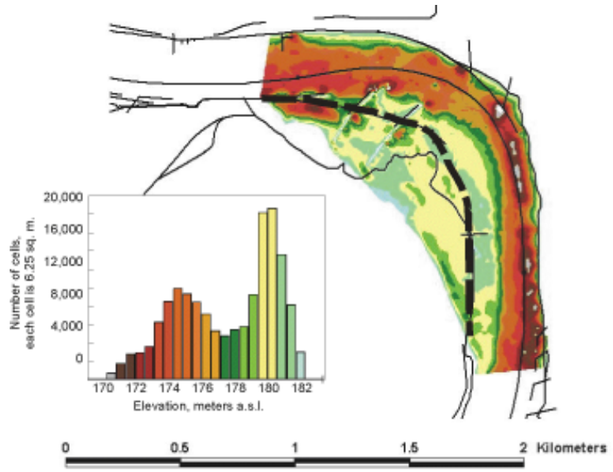


Figure A.
Additional shallow-water habitat was created by the U.S. Army Corps of Engineers at the Jameson Island site. The map shows surface elevations at the site after widening of the channel; the bar chart shows two peaks in the distribution of elevations – one for the navigation channel and one reflecting the area of new shallow-water habitat. Stage-discharge relations surveyed at this site have been used to combine hydrology and channel morphology to calculate how much shallow-water habitat is available at different times of the year (fig. B).

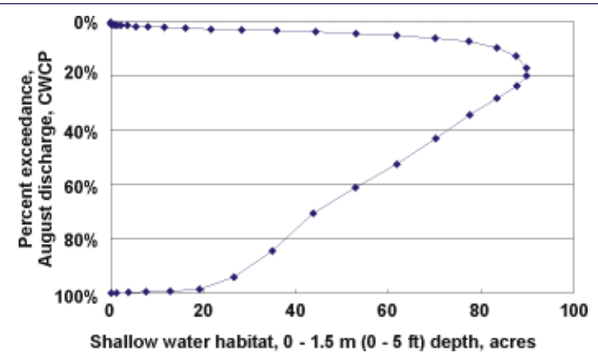


Figure B.
Graph of how much and how often shallow-water habitat is available at Jameson Island in August under the Current Water Control Plan. The maximum amount of habitat (about 90 acres) is available at flows that are equaled or exceeded only 20% of the time in August. About 62 acres are available during the median flow, equaled or exceeded 50% of the time.

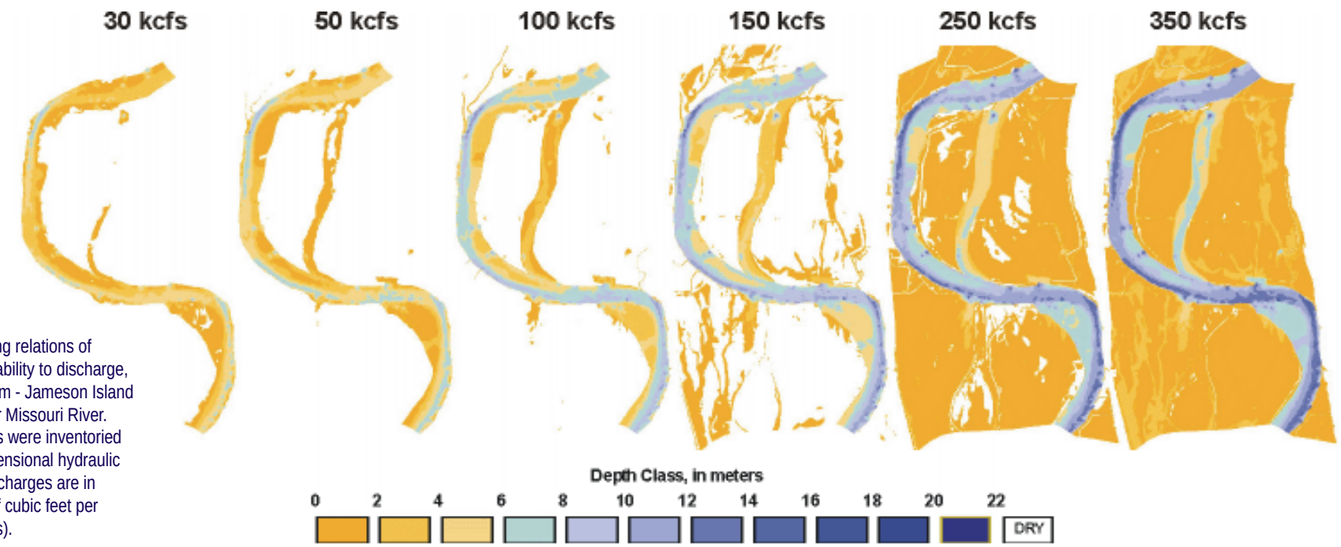
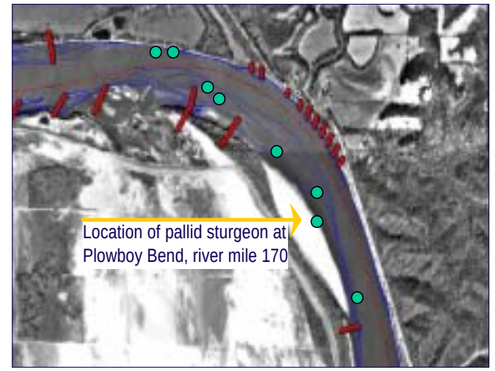


Figure C.
Maps showing relations of habitat availability to discharge, Lisbon Bottom - Jameson Island reach, Lower Missouri River. Water depths were inventoried with a 1-dimensional hydraulic models. Discharges are in thousands of cubic feet per second, (kcfs).

Pallid Sturgeon Habitat Use

Pallid sturgeon are rarely captured in the Lower Missouri River and little information exists on habitats used by the fish in this region. To aid in the recovery of the species and to guide habitat rehabilitation efforts, it is crucial that managers know what habitats pallid sturgeon use and why (spawning, feeding, over-wintering), as well as where the habitats are located and how much is needed.



Telemetry is a tool used to identify where individual pallid sturgeon are located at any point in time.

Scientists at CERC investigate the habitat requirements of sturgeon using specialized telemetry methods to track them. The fish are surgically implanted with acoustic telemetry location tags and small archival devices that continuously record the temperature and depth of the habitats selected by the fish. The goal is to locate and recapture fish after several months to retrieve the archival tag and to examine changes in reproductive status over time. The surgical procedure is minor and CERC biologists have had no fish mortality from implanting the transmitters.

Initial studies from 1995-1998 were conducted on 30 pallid sturgeon transplanted from the middle Mississippi River. Sturgeon can move rapidly; movements of more than 24 miles downstream and 15 miles upstream were observed in one day. Fish prefer sand substrate at the margins of the river channel, near sand islands, and off the ends of wing dikes in currents with moderate velocity. They appear to show a strong affinity for areas with complex current patterns and bottom topography or bedforms, but are rarely found in the main channel and appear to avoid backwater areas and areas without current.

This year, CERC scientists established six automated telemetry receiving stations between Hermann, Missouri and Lisbon Bottom (river mile 90 to 220) to track pallid sturgeon. Again the rarity of the fish was demonstrated. Out of several thousand sturgeon captured by U.S. Fish and Wildlife Service (FWS) and CERC, only five were pallid sturgeon; of those, only two were sufficient size for implantation of acoustic transmitters and archival tags. Each month, biologists searched over 800 miles of river to locate the tagged sturgeon. Hydrologists conducted quantitative habitat assessments at locations where sturgeon are found. These data will be incorporated into hydraulic models to refine estimates of habitat availability.

To understand environmental variables affecting the fish, temperature-recording devices were placed in the river at multiple locations to document the relationship between discharge and water temperature. Water temperatures within the range thought to be suitable for pallid sturgeon spawning occurred coincident with high-water events during mid-May in the Lower Missouri River.

During the spring of 2002, habitat assessment protocols were developed and validated using flathead catfish fitted with radio transmitters which demonstrated that fish locations could be accurately located on hydroacoustic maps of depth, velocity, and substrate. Habitat assessment tools were employed in early August 2002 to map habitat used by pallid sturgeon in the Fort Randall segment of the Missouri River (fig. Map), in collaboration with the FWS and U.S. Army Corps of Engineers. Pallid sturgeon with ultrasonic transmitters were located, and their habitats mapped with hydroacoustics to quantify late-summer habitat usage.